Letter to the Editor

Medical Assessment on Forest Therapy Base in Zhejiang Province, China*

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According to the '13th Five-Year plan for forestry development' of State Forestry and Grassland Administration, 500 forest therapy (also known as forest bathing or Shinrin-yoku in Japan) bases and 5–10 international cooperation demonstration bases will be set up in China, by 2020. So, it's important to provide evidence about the benefits of specific forest environmental to human health, namely medical assessment on forest therapy base.

Entrusted by Forest Therapy Committee, Chinese Society of Forestry, here, we presented an international cooperation project, medical assessment on Yaolin National Forest Park, in Tonglu City, Zhejiang Province, China. This study enrolled 31 patients with or without HTN from Hangzhou. They were randomly divided into two groups: 11 in suburban group (as a control) and 20 people in forest group according to the ratio of 1:2. The inclusion and exclusion criteria was described as previously[1]. Two groups were activated according to this procedure: On the first day, the subjects walked along a predetermined course in each area at an unhurried pace for about 1.5 h. In the afternoon, the subjects were arranged to enjoy the tea art. On the second day, the subjects walked as the first day, at afternoon, the subjects were arranged to sit quietly for 1.5 h. On the morning of the third day, subjects were sampled the blood before breakfast. After breakfast, both two groups were taken to Hangzhou city. This study was approved by the ethics committee of Zhejiang Hospital and informed consent was signed by every subject.

Systolic blood pressure (SBP), diastolic blood pressure (DBP) and HR were obtained from the right arm using a portable digital sphygmomanometer (HEM-7000-E, Omron, Kyoto, Japan). The fingertip pulse oximeter (YUWELL YX301) was used to measure SpO_2%. The standard version of the POMS questionnaire was used to measure mood states[2]. HRV, including low frequency (LF), high frequency (HF) and the ratio of low frequency and high frequency (LF/HF) were assessed by SA-3000P (Medicore Inc., Seoul, Korea). The number of steps and calories consumed during the experiment were recorded using Smart bracelet (Deepiot, BM-8, Xinzhigan Technology Co., Ltd, Beijing, China). Plasma level of high-sensitive-reactive protein (hs-CRP), Cortisol, superoxide dismutase (SOD) and Malondialdehyde (MDA) (Elabscience Biotechnology Co., Ltd, Wuhan, China) were determined by ELISA kits according to the manufacturer's instruction. The level of negative oxygen ions, the concentration of particulate matter $(PM)_{2.5}$ and PM_{10}, and the other environment factors, including wind velocity, temperature, humidity and climatic comfort index (CCI) were measured as described in previous study[1]. Categorical variables were compared by Chi-square analysis. T-test was used to compare continuous data. All statistical analyses were completed using the SPSS 19.0 software (SPSS China, Shanghai, China), $P < 0.05$ was considered statistically significant.

The clinical characteristics of the participants are shown in Supplementary Table S1 (available in www.besjournal.com). The gender, age, body mass index (BMI), and baseline levels of SBP, DBP, HR, SpO_2%, HRV, POMS score were not significantly different between the two groups. In addition, no significant differences in the baseline values of biological indicators, including serum hs-CRP, cortisol, SOD, and MDA, were observed between the two groups, either.

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First, we observed the effect of forest bathing on BP, HR, SpO_2%, and HRV. As shown in Table 1, after three-day forest bathing, participants in Yaolin National Forest Park showed a significant decrease in DBP (73.40 ± 5.97 *vs*. 80.73 ± 7.31, $P < 0.01$), but increase in SpO_2% (98.00 ± 0.80 *vs*. 97.09 ± 1.14, $P < 0.05$) and HF (64.36 ± 14.57 *vs*. 44.91 ± 23.55, $P < 0.01$), when compared with control group. In this study, the level of BP was slightly increased in both two groups after forest bathing, although it had no significance. The reason of this result might be the new environment participants entered. Then, we determined the influence of forest trip on serum bio-markers on patients with HTN. We found that, SOD, a kind of important antioxidant substance, was reduced in both two groups after experiment. These results would attribute to the high altitude of the experimental sites, the more strong sunlight, and more excises they take than their daily life. But, lesser reduction of SOD was found in forest group (23.67 ± 12.10) than in control group (30.15 ± 8.12, $P > 0.05$). As a results, after forest bathing, the level of SOD was significantly enhanced in experiment group than control group (36.22 ± 10.20 *vs*. 24.47 ± 8.57, $P < 0.01$) (Table 2).

It has been reported that there is a positive association between anxiety and hypertension[3]. As shown in Table 3, the scores of the participants who experienced a forest bathing trip in the negative subscales, including tension-anxiety (T) (12.00 ± 4.22 *vs.* 17.33 ± 4.56, $P < 0.01$), depression-dejection (D) (21.25 ± 7.59 *vs.* 30.83 ± 8.96, $P < 0.01$), anger-hostility (A) (17.60 ± 5.99 *vs.* 23.25 ± 8.36, $P < 0.05$), fatigue-inertia (F) (11.10 ± 4.90 *vs.* 15.33 ± 3.55, $P < 0.05$), and confusion-bewilderment (C) (11.90 ± 3.60 *vs.* 14.67 ± 4.85, $P < 0.05$), were significantly lowered, when compared with the city group (Table 3). In contrast, a significant elevated score in the positive subscale vigor-activity (V) was observed (24.10 ± 2.40 *vs.* 19.25 ± 4.98, $P < 0.01$). These results were in line with our previous studies showed that forest therapy may improve the mood of the patients with HTN[1,4,5]. Therefore, it's reasonable to speculate that forest environment exert benefits to our BP, at least in part, due to psychological relaxation and mood improvement.

It's well known that amount of exercise and calories consumption may influence BP, HR and SpO_2%, etc. So, we calculated the number of steps and calories consumed during the experiment. As shown in Supplementary Table S2 (available in www.besjournal.com), there was no obvious difference in amount of exercise and calories consumption between experiment group and control group, suggesting that the above changes, including DBP, SpO_2%, HF, SOD, and POMS score, were independent of the amount of exercise and calories

Table 1. Effect of forest bathing on BP, HR, SpO_2, and HRV (Mean ± SD)

Items	Control group	Experiment group
SBP (mmHg)	141.82 ± 14.90	134.50 ± 12.92
DBP (mmHg)	80.73 ± 7.31	73.40 ± 5.97**
HR (bpm)	64.91 ± 5.21	66.10 ± 7.41
SpO_2 (%)	97.09 ± 1.14	98.00 ± 0.80*
LF (ms^2)	41.45 ± 25.00	41.29 ± 21.21
HF (ms^2)	44.91 ± 23.55	64.36 ± 14.57**
LF/HF	1.17 ± 1.33	1.55 ± 3.37

Note. Compared with control group, $^{*}P < 0.05$; $^{**}P < 0.01$. Abbreviation: SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; SpO_2, pulse oxygen saturation; HRV, heart rate variability; LF, low frequency; HF, high frequency; LF/HF, the ratio of low frequency and high frequency.

Table 2. Effect of forest therapy on bio-markers (Mean ± SD)

Items	Control group	Experiment group
hs-CRP (pg/mL)	449.34 ± 305.04	817.21 ± 1,593.22
Cortisol (ng/mL)	45.60 ± 48.35	47.17 ± 53.65
MDA (ng/mL)	159.94 ± 67.76	162.00 ± 85.08
SOD (UI)	24.47 ± 8.57	36.22 ± 10.20**

Note. Compared with control group, $^{**}P < 0.01$. hs-CRP, high-sensitive-reactive protein; MDA, malondialdehyde; SOD, superoxide dismutase.

Table 3. Influence of forest environment on mood (Mean ± SD)

Items	Control group	Experiment group
Tension-anxiety (T)	17.33 ± 4.56	12.00 ± 4.22**
Depression-dejection (D)	30.83 ± 8.96	21.25 ± 7.59**
Anger-hostility (A)	23.25 ± 8.36	17.60 ± 5.99*
Vigor-activity (V)	19.25 ± 4.98	24.10 ± 2.40**
Fatigue-inertia (F)	15.33 ± 3.55	11.10 ± 4.90*
Confusion-bewilderment (C)	14.67 ± 4.85	11.90 ± 3.60*

Note. Compared with control group, $^{*}P < 0.05$; $^{**}P < 0.01$.

consumption.

Finally, the air quality in both sites was monitored simultaneously. Our results revealed a significantly higher level of negative ions in the forest environment (1335.00 ± 158.62/cm^3) than in the urban area (879.67 ± 234.53/cm^3). On the contrary, a significantly lower level of TSP (47.68 ± 5.94 *vs.* 86.32 ± 20.80, $P < 0.05$), PM_{10} (24.53 ± 3.26 *vs.* 45.25 ± 10.49, $P < 0.05$), $PM_{2.5}$ (5.10 ± 0.85 *vs.* 7.48 ± 1.14, $P < 0.05$) and PM_1 (0.76 ± 0.16 *vs.* 1.32 ± 0.22, $P < 0.05$) was recorded in the forest environment than in the urban area. Besides, although Mid August is the hottest days of the year in Hangzhou City, forest environment was much more comfortable than control group, as indicated by the temperature (30.65 ± 1.08 *vs.* 34.27 ± 1.89, $P < 0.05$) and CCI (86.67 ± 1.53 *vs.* 90.67 ± 2.52, $P < 0.05$), except for the humidity (68.09 ± 4.23 *vs.* 57.94 ± 3.34, $P < 0.05$) (Supplementary Table S3 available in www.besjournal.com). Therefore, the possible mechanisms by which Forest environment could contribute to reduce BP, improve mood, and increase antioxidant activity can be summarized as follows. The First, forest environment may provide beneficial physiological effects include the aroma of plants as well as such various factors as temperature, humidity, light intensity, wind, and oxygen concentrations[6]. Second, investigation showed that a higher number of negative ions were beneficial for down-regulating the DBP[7]. Third, increasing epidemiologic and controlled human studies have reported that short- or long-term exposure to PM_{10} was related with higher SBP or DBP[8-10].

In Japan, forest therapy base is well development, but it is nearly blank in our country. Over the past decade, we conducted some studies evaluating the influence of forest environment on human health in different forest therapy bases, including Wuchaoshan National Forest Park[1], Baimashan Forest Park[1,11] and Huangtan Forest Park[12,13]. These previous researches demonstrated the benefits of forest environment on physiological relaxation and immune functions improvement[1], as well as the adjuvant therapeutic effects on patients with hypertension (HTN)[1], chronic obstructive pulmonary disease (COPD)[11], and chronic heart failure (CHF)[12,13]. In order to further promote the development of the forest therapy base in China, it is necessary to launch an international cooperation project on medical assessment of forest therapy base. However, related studies have not been reported so far. In this international cooperation project, we optimized the bio-markers and improved the experimental procedure. These improvements minimized the costs of the forest medical assessment and make it easy to operate.

In conclusion, the current study demonstrated that forest environment in Yaolin National Forest Park, in Tonglu Hangzhou city, Zhejiang province, could provide many benefits to the elderly patients with HTN. This international project would benefit to the transformation and development of forestry economy in China, and greatly enriches the content of China's health industry, and also promote the exchanges with international about forest medicine. However, in order to further promote the development of the forest therapy base in China, much more international cooperation projects on medical assessment of forest therapy base is an urgent call to action.

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REFERENCES

1. Mao GX, Cao YB, Lan XG, et al. Therapeutic effect of forest bathing on human hypertension in the elderly. J Cardiol, 2012; 60, 495−502.
2. Pollock V, Cho DW, Reker D, et al. Profile of Mood States: the factors and their physiological correlates. J Nerv Ment Dis, 1979; 167, 612−4.
3. Player MS, Peterson LE. Anxiety disorders, hypertension, and cardiovascular risk: a review. Int J Psychiatry Med, 2011; 41, 365−77.
4. Yu CP, Lin CM, Tsai MJ, et al. Effects of short forest bathing program on autonomic nervous system activity and mood states in middle-aged and elderly individuals. Int J Environ Res Public Health, 2017; 14, 897−909.
5. Ochiai H, Ikei H, Song C, et al. Physiological and psychological effects of forest therapy on middle-aged males with high-normal blood pressure. Int J Environ Res Public Health, 2015; 12, 2532−42.
6. Kawakami K, Mai K, Nomura M, et al. Effects of phytoncides on blood pressure under restraint stress in SHRSP. Clin Exp Pharmacol Physio, 2010; 31, S27−8.

7. Ryushi T, Kita I, Sakurai T, et al. The effect of exposure to negative air ions on the recovery of physiological responses after moderate endurance exercise. Int J Biometeorol, 1998; 41, 132−6.
8. Fuks K, Moebus S, Hertel S, et al. Long-term urban particulate air pollution, traffic noise, and arterial blood pressure. Environ Health Perspect, 2011; 119, 1706−11.
9. Chuang KJ, Yan YH, Cheng TJ. Effect of air pollution on blood pressure, blood lipids, and blood sugar: a population-based approach. J Occup Environ Med, 2010; 52, 258−62.
10. Szu-Ying C, Ta-Chen S, Yu-Lun L, et al. Short-term effects of air pollution on pulse pressure among nonsmoking adults. Epidemiology, 2012; 23, 341−8.
11. Jia BB, Yang ZX, Mao GX, et al. Health Effect of Forest Bathing Trip on Elderly Patients with Chronic Obstructive Pulmonary Diseas. Biomed Environ Sci, 2016; 29, 212−8.
12. Mao GX, Cao YB, Wang BZ, et al. The Salutary Influence of Forest Bathing on Elderly Patients with Chronic Heart Failure. Int J Environ Res Public Health, 2017; 14, 368−79.
13. Mao GX, Cao YB, Yang Y, et al. Additive Benefits of Twice Forest Bathing Trips in Elderly Patients with Chronic Heart Failure. Biomed Environ Sci, 2018; 31, 159−62.

Supplementary Table S1. Baseline characteristics of the participants

Items	Control group	Experiment group
Gender (M/F)	6/5	12/8
Age (year)	71.64 ± 5.70	73.60 ± 6.39
BMI (kg/m^2)	23.93 ± 2.67	22.80 ± 2.36
SBP (mmHg)	131.09 ± 17.82	127.70 ± 14.44
DBP (mmHg)	69.36 ± 8.93	68.35 ± 6.99
HR (bpm)	78.27 ± 11.90	77.00 ± 10.12
SpO_2 (%)	96.82 ± 1.08	97.10 ± 1.25
LF (ms^2)	44.90 ± 19.43	39.12 ± 19.23
HF (ms^2)	55.10 ± 19.43	55.88 ± 21.40
LF/HF	1.26 ± 1.60	0.85 ± 0.76
hs-CRP (pg/mL)	247.68 ± 277.86	221.60 ± 166.83
Cortisol (ng/mL)	74.70 ± 40.40	69.19 ± 58.66
MDA (ng/mL)	232.48 ± 73.18	225.55 ± 89.30
SOD (UI)	54.62 ± 9.17	59.89 ± 15.01
tension-anxiety (T)	18.67 ± 4.40	16.95 ± 3.61
depression-dejection (D)	32.33 ± 7.75	30.75 ± 6.86
anger-hostility (A)	25.67 ± 6.57	23.20 ± 5.60
vigor-activity (V)	19.58 ± 4.32	20.10 ± 2.20
Fatigue-inertia (F)	16.92 ± 6.68	16.40 ± 3.42
confusion-bewilderment (C)	15.33 ± 4.40	14.25 ± 3.70

Note. All *P* values > 0.05.Abbreviation: BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; SpO_2, pulse oxygen saturation; HRV, heart rate variability; LF, low frequency; HF, high frequency; LF/HF, the ratio of low frequency and high frequency; hs-CRP, high-sensitive-reactive protein; MDA, malondialdehyde; SOD, superoxide dismutase; POMS, profile of mood states.

Supplementary Table S2. Amount of exercise and calories consumption

Group	Control group	Experiment group
Number of steps	13,230.60 ± 6,170.26	14,225.90 ± 242.90
Calories consumption(kcal)	584.30 ± 242.90	631.05 ± 278.88

Note. All p values > 0.05.

Supplementary Table S3. Comparison of air quality and environment factors assessment

Items	Control group	Experiment group
Wind velocity (m/s)	1.26 ± 0.48	0.40 ± 0.27
Temperature (℃)	34.27 ± 1.89	30.65 ± 1.08*
Humidity (%)	57.94 ± 3.34	68.09 ± 4.23*
Negative ions (cm^{-3})	879.67 ± 234.53	1,335.00 ±158.62*
TSP (mg/m^3)	86.32 ± 20.80	47.68 ± 5.94*
PM_{10} (mg/m^3)	45.25 ± 10.49	24.53 ± 3.26*
$PM_{2.5}$ (mg/m^3)	7.48 ± 1.14	5.10 ± 0.85*
PM_1 (mg/m^3)	1.32 ± 0.22	0.76 ± 0.16*
CCI	90.67 ± 2.52	86.67 ± 1.53*

Note. Compared with the control group, $^*P < 0.05$. Abbreviation: TSP, total suspended particle; PM_{10}, particulate matter considered as mass defined by a size cutoff at 10 μm in aerodynamic diameter; $PM_{2.5}$, particulate matter considered as mass defined by a size cutoff at 2.5 μm in aerodynamic diameter; PM_1, particulate matter considered as mass defined by a size cutoff at 1 μm in aerodynamic diameter; CCI: climatic comfort index.